Summary of Groundwater Model Construction for Barrier Wall

Premier Edible Oils

Portland, Oregon

Introduction

Three steady-state groundwater simulations were constructed for the Premier Edible Oils (PEO) site located adjacent to the Willamette River near Portland Oregon. The objective if these simulations was to assess the hydraulic performance of a proposed barrier wall to mitigate further migration of LNAPL towards the Willamette River. Three steady-state numerical groundwater models were constructed to simulate variations in wall depth. Groundwater flow modeling and particle tracking were done using the GMS v9.0 groundwater modeling platform. The numerical model MODFLOW2000 (USGS, 2000), integrated with the GMS platform, was used to solve the groundwater flow equation. Hydraulic performance was assessed using the USGS software MODPATH 6.0 which is also integrated with the GMS platform.

Grid Dimensions

The model grid is 1,750 feet wide in the northwest-southeast direction; 1,400 feet wide in the northeast-southwest direction; with a maximum thickness of 150 feet at the northeast model boundary. The horizontal dimension of model cells is ten by ten feet over the entire grid. The thicknesses of the upper model layers vary in relation to the thickness of the silt confining unit.

The model as well as the shapefiles include with this data package are in State Plane Coordinate System (NAD83), Zone: Oregon North, in feet.

Model Layering

The model has five layers representing four hydrostratigraphic zones:

- Zone 1 – Upper Sand (alluvium)
- Zone 2 – Silt Confining Unit(river over-bank deposits)
- Zone 3 – Lower Sand (interlayered river channel and over bank deposits)
- Zone 4 – Deep Sand (fine to medium sand with low silt content)

Simulating a groundwater flow barrier of varying depth using MODFLOW and the Horizontal Flow Barrier Package required splitting Zone 3 into two “subzones”. The elevation/depth of the boundary between subzones corresponds to the elevation/bottom of the simulated barrier wall as required per scenario. The thickness and horizontal extent of the silt confining unit (Zone 3) was based a composite of multiple silt lenses of varying size and thickness separating the Upper and Lower Sands.

Hydraulic Conductivity Distribution

Hydrostratigraphic Zone	$K_{horizontal}/K_{vertical}$ (ft/d)	Zone Thickness Near LNAPL Impacts (ft)	Source
Upper Sand	8.78 / 0.878	36	Geometric mean of T&R slug testing
Silt Confining Unit	0.5 / 0.005	1	Papadopoulos, 2007
Lower Sand	8.78 / 0.878	35	Geometric mean of T&R slug testing
Deep Sand	65/6.5	70	Landau, 2005;

Effective Porosity

0.3 for all layers.

Aquifer Recharge

A uniform aquifer recharge rate of 0.00228 ft/d (10 inches/year) was applied. This estimate is based on 27% infiltration of precipitation in unpaved areas (Environmental Resource Management, 2007) using results from precipitation runoff modeling of the Willamette River Basin. Total precipitation for the Portland area is 37.4 in/year from 1975 to 2005 (Environmental Resource Management, 2007).

Willamette River Stage

Average river stage: Average river stage is from the USGS surface water gage 14211720, located about 8.5 miles upriver from the PEO site. Average gage height for December 2012 through December 2013 was 4.85 feet. This value was converted to City of Portland (COP) vertical datum for a final value of 4.675 feet-COP.

Maximum River Stage: The maximum observed river stage is 15.80 ft-gage or 15.625 ft-COP, found in "extremes for the year" in the 2012 Water Data Report for the USGS surface water gage 14211720.

Willamette River Bottom Elevation

The river bottom is set equal to an elevation of -29.0 ft-COP, based on T&R cross sections A-A' (Figure 3, drawing date 12/27/12). The cross-section bathymetry data is from NOAA draft Portland Harbor Area Riparian Area Analysis 2012. Average water column thickness near the PEO site is 33.6 feet.

Willamette Riverbed Conductance

Estimated to be 100,000 $(ft^2/d)/(ft^2)$. This assumes sediments provide little resistance to exchanges between aquifer and river.

Boundary Conditions

No-Flow: Along the northwest and southeast grid the no-flow boundaries represent groundwater flow paths (i.e., flow is parallel to the no-flow boundary). The bottom of the model is also no flow boundary representing the interface between local and regional flow systems.

Constant Head: The northeast model boundary is assigned a head value of 16 ft-COP in all model layers. This value is characteristic of the water table elevation along the northeast PEO property line. The southwest model boundary is represented by the Willamette River with a constant river stage elevation.

Hydraulic Barrier

Length: 400 feet.
Depth: 30 or 40 feet below grade, depending on simulation.
Conductance: Barrier is assumed to be impermeable.

MODFLOW Simulation Construction Summary

- PEO_Model_13a: proposed wall is 30 feet deep and Willamette River is at average stage.
- PEO_Model_14a: proposed wall is 40 feet deep and Willamette River is at average stage.
- PEO_Model_14c: proposed wall is 40 feet deep and Willamette River is at maximum stage.

MODPATH Simulation Construction Summary

MODPATH simulations were run using results from each of the MODFLOW2000 simulations mentioned above. All three MODPATH simulations use forward particle tracking beginning with single particles placed on the water table at wells RW-1, MW-08, MW-09, MW-12, MW-18, MW-23, MW-24 and MW-25; and tracked to their point of discharge to the Willamette River.

REFERENCES

1. Environmental Resource Management Group, Inc. December 2007. DRAFT Groundwater Modeling Report, Arkema, Inc. Facility, Portland, Oregon.
2. Gradient Corp. June1, 2011. Remedial Investigation Report for the Premier Edible Oils Site, Portland, Oregon
3. Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 p.
4. Landau Associates. 2005. Time Oil Northwest Terminal Phase III Remedial Investigation Report.
5. Pollock, D.W. 2012 User Guide for MODPATH Version 6 - A Particle-Tracking Model for MODFLOW: Techniques and Methods 6-A41
6. S.S. Papadopulos & Associates, Inc. October 30, 2007. NW Natural Gasco, Pump Test and MODFLOW Model Summary, 70 p.
7. Treadwell & Rollo. February 29, 2012. Investigation Workplan for Removal Action Southern Portion of Premier Edible Oils Site 10400 North Burgard Way, Portland, Oregon.

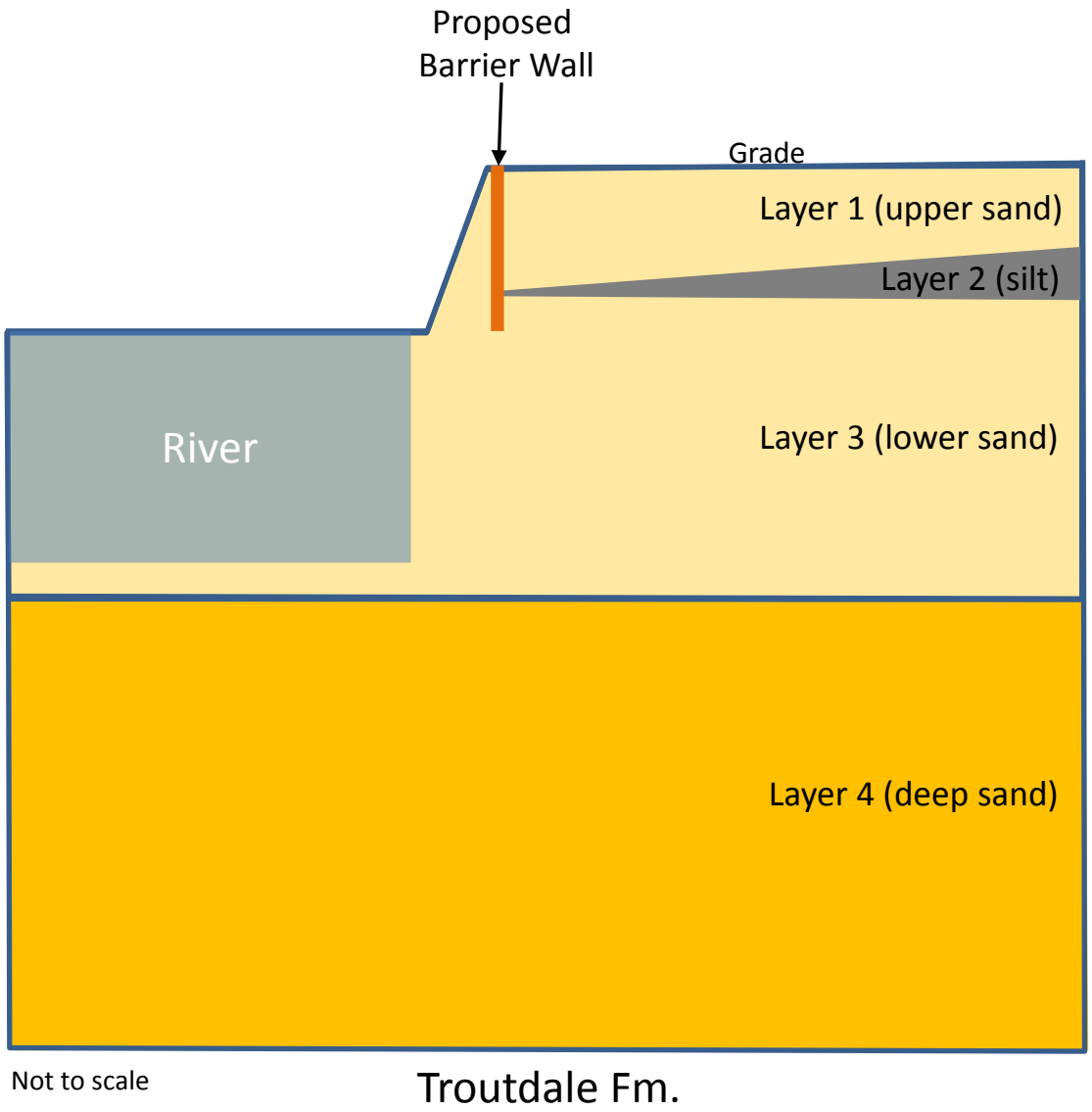

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Figure 1. Conceptual Groundwater Model Grid

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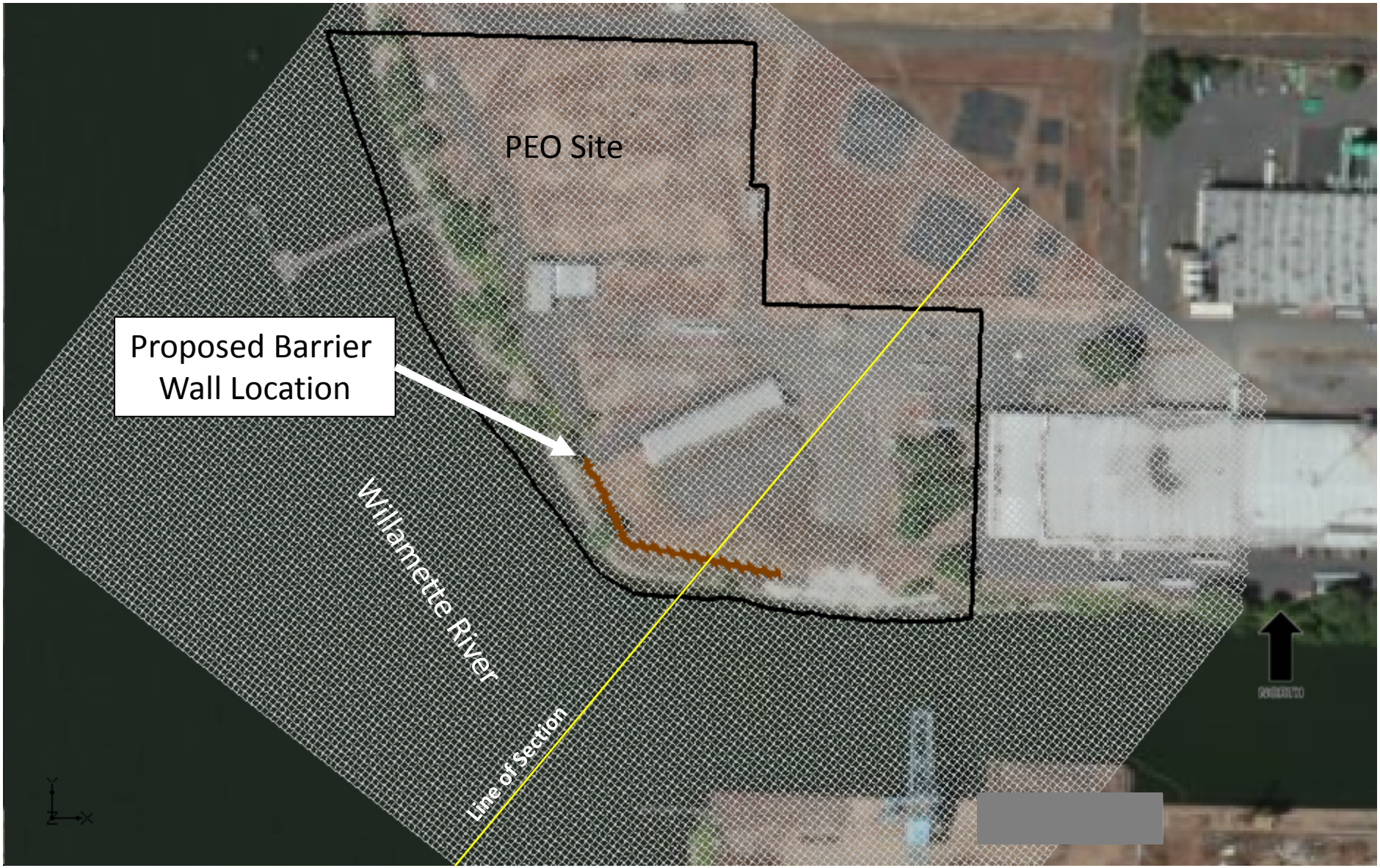

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Figure 2. Groundwater model grid with location of proposed barrier wall.

Treadwell&Rollo

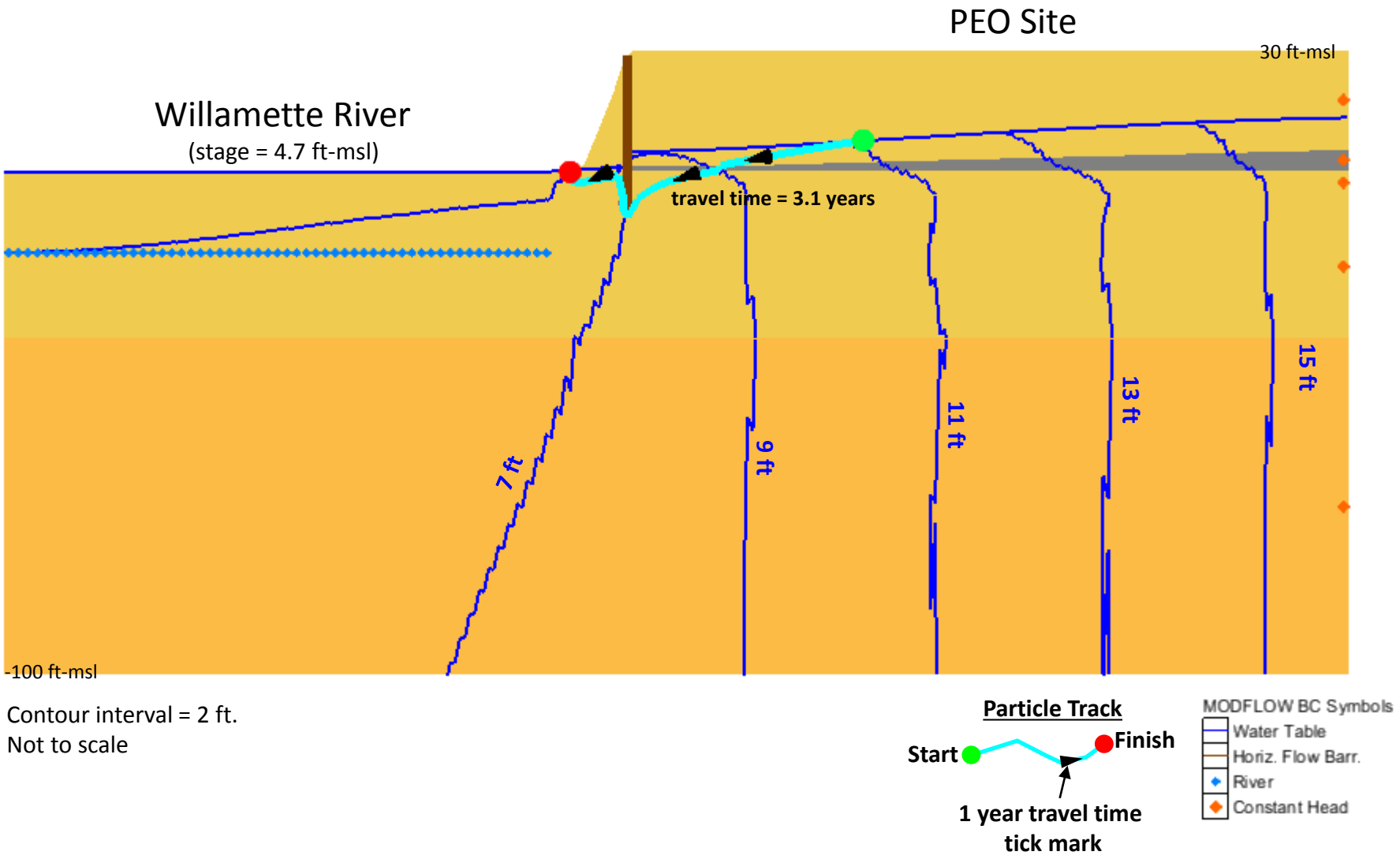

Figure 3. Cross section depicting simulated groundwater flow and particle track for a barrier wall depth of 30 feet below ground surface at average river stage.

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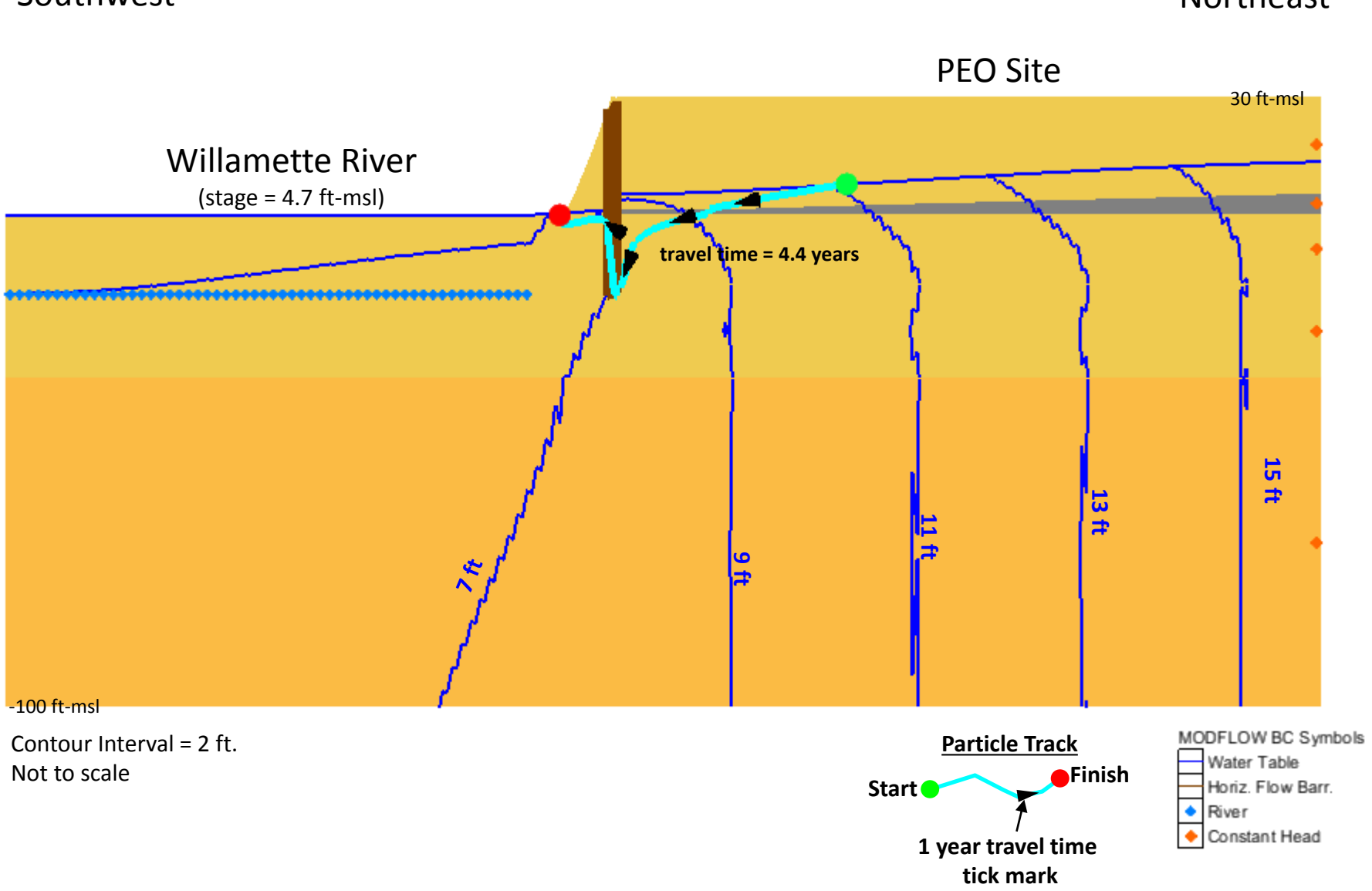

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Figure 4. Cross section depicting simulated groundwater flow and particle track for a barrier wall depth of 40 feet below ground surface at average river stage.

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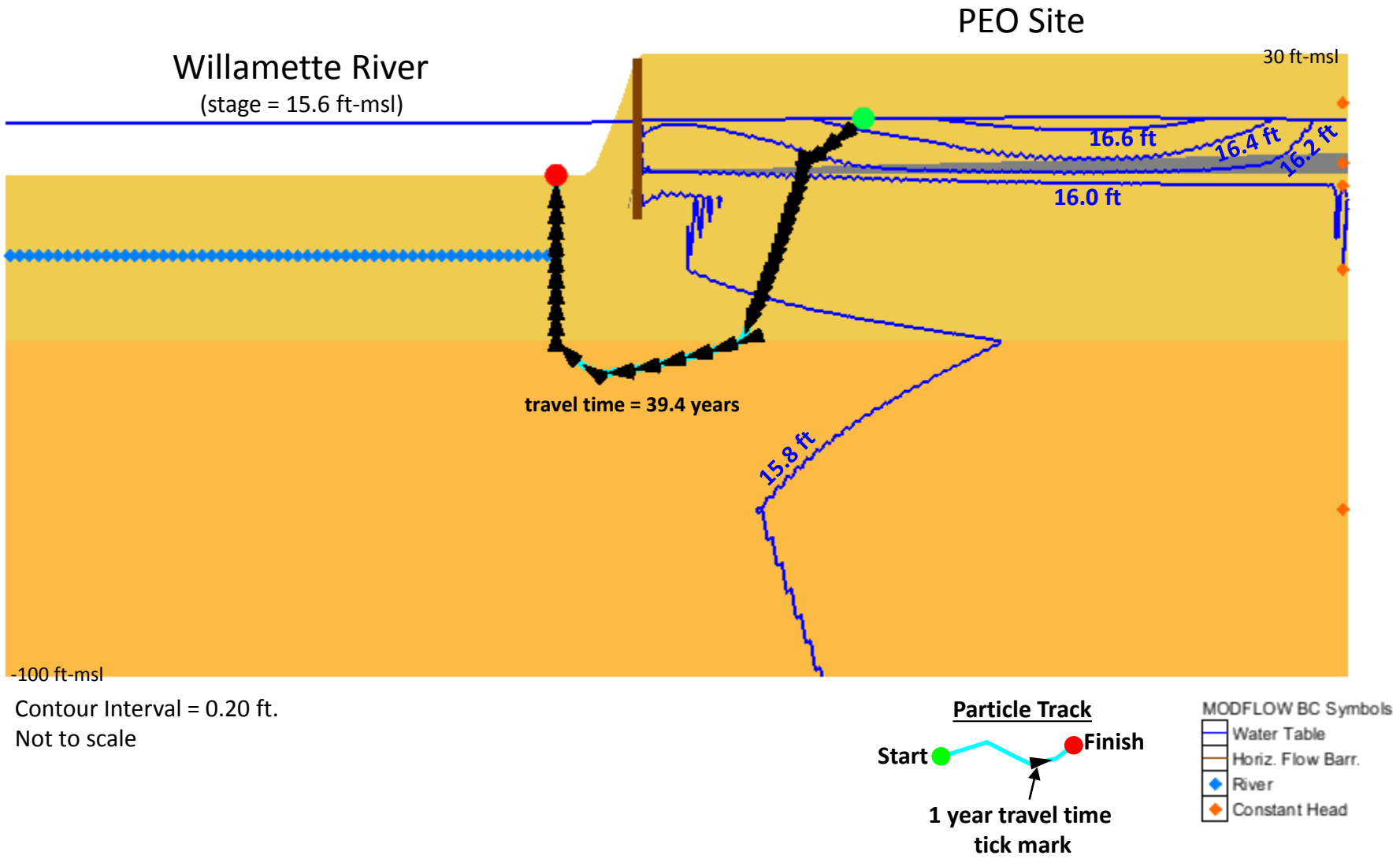

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Figure 5. Cross section depicting simulated groundwater flow and particle track for a barrier wall depth of 40 feet below ground surface at maximum river stage.

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